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Client/Server Technology: Is It Beneficial in the Engineering Information and Information Technology Environment?

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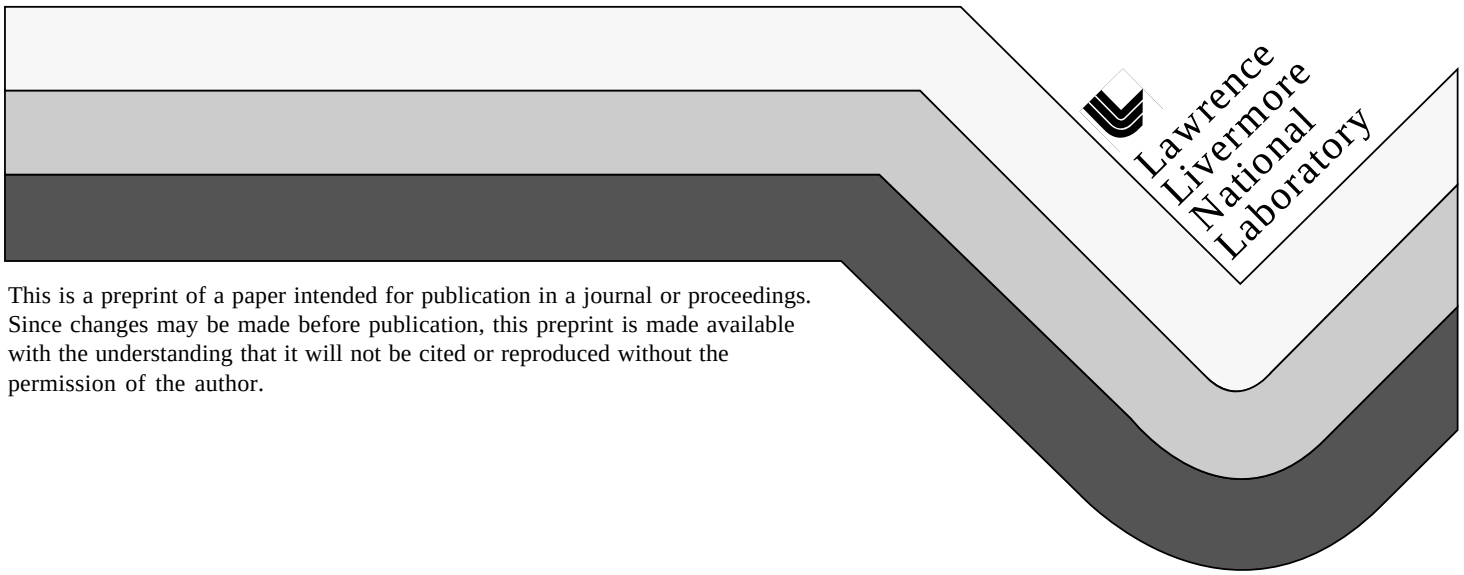

Client/Server Technology: Is It Beneficial in the Engineering Information and Information Technology Environment?

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Abstract

Client/server systems have been touted as the next step in the advance of the computer into modern, computer-aided drafting (CAD), computer-aided engineering (CAE), geographical information systems (GIS), engineering information (EI) technology, and information technology (IT) society, but they are not a solution to every organization's problems when it comes to advanced computer technology. Some of the ideas that are presented here are "old hat." Then I ask you, why don't we follow there "old hat" principles? This paper attempts and explores the advantages and disadvantages of these popular systems.

The client/server architecture, apart from its ability to manage CAD/CAE/GIS and EI/IT and deliver it to decision makers in a timely fashion, offers many compelling advantages. There is, however, a downside to the widespread acceptance of the client/server environment. Users who expect to save money may be very disappointed. This paper provides a set of guidelines to help senior managers determine whether client/server computing is right for their CAD/CAE/GIS and IT organizations. From this point on, the abbreviations, CAD/CAE/GIS and EI/IT will be jointly referred to as "EI/IT" systems.

Introduction

Some individuals within the Lawrence Livermore National Laboratory's (LLNL's) Plant Engineering (PE) organization, inside the computer industry, and in business feel that the *current headlong rush into the adoption of client/server technology may be ill-conceived.* The client/server model is very robust from a theoretical standpoint. However, having a sound theoretical model does not ensure success in any organization. As with any new system, thorough analysis and design is necessary to ensure success. *Implementing and maintaining client/server systems involves other costs that may surprise hopeful system purchasers.*

Client/server computing technology is one of the most overused and least defined buzz phrases in the computing industry. If a dozen people were asked to define it, they would come up with two dozen answers. However, almost everyone agrees that it is a critical component in almost every organization's EI/IT architecture.

To implement client/server systems, in most situations both developers and user must acquire *some* new skills in addition to new software, and hardware. Training time and expense is a problem often overlooked, or underestimated, in the planning stages of client/server systems implementation. *Role changes,* both within and without a EI/IT organization, *can* affect likely system success. The selection and installation of hardware and software for your organization may affect your system's performance. You may

also find that the so-called true client/server systems may really be variations on other types of systems.

Defining the Client/Server Technology

The definition of client/server technology changes, depending on the situation. According to Paul Renaurd, "The key to understanding client/server technology is in realizing that it is a logical concept. . . . More precisely, client/server technology is a paradigm, or model, for the interaction between concurrently executing software processes." The differences encountered in the definition of client/server are a result of varying interpretations of the idea of "concurrently executing software processes."(1) In a simple version, a user interface interacting with an application program is a client/server relationship. At the other extreme, a central server on a mainframe computer interacts with thousands of remote clients on desktop computers.

In the basic theoretical relationship, a client process requests information from a server process. The server performs the requested action and returns the resulting information. Servers do NOT initiate communication with clients, and they do NOT communicate with other servers. The client and the server operate as peers, exhibiting cooperative interaction but remaining independent. The relationship is transparent to the user, who is unaware of the division of the computing task between the client and the server.

This scenario could provide your organization with a seamless, single-system view of the computing environment to the end user. In practice, the client and server processes usually run on separate machines communicating over a network.

Components of Client/Server Systems

In the client/server model, applications may exist in one of three forms. This may help crystallize what a client/server consists of:

- In the first, the application may exist entirely on the client, only requesting data from the server.
- In the second, the application may exist primarily on the server, with the client providing an interface to the server application and doing very little processing.
- In the third, a portion of the application may exist on the client and server so that different parts of the processing occur on the client and the server.

As your organization's EI/IT project expands its operations to encompass *all* of its associated organizations, both large and small, this framework will ensure that the appropriate people and software/hardware are assigned to deal with current and future needs.

Client

In the client / server relationship, the client uses the services provided by one or more server processes. It is the proactive member of the relationship, issuing requests to the server and receiving responses. *An application program is not the client; rather, it provides the mechanism for a client session.* A client is dedicated to an individual user. It comes into existence at the beginning of a user session and ends when the user session ends.

The application software on the client handles the screen interface to the user. It accepts inputs from the user, validates the input data, provides error recovery, and returns the requested information. Once data is received from the user, the application software formulates and sends requests for service to the server. It accepts replies from the server and performs all logical or functional tasks required to fulfill the user's specifications.

The operating system software provides two different services:

- First, it provides the services used by the application software to control the hardware (i.e., the screen output and the keyboard input).
- Second, it provides network communication capability, allowing the client to communicate with the server when they are located on separate machines.

In the usual implementation of a client / server system, the client process is handled by a desktop computer.

Server

A server is a reactive process activated by requests sent from the clients. It runs continuously and provides service to any number of clients. The server performs requested transactions and does NOT interact with any other servers.

The operating system software on a server performs the same activities as it does on a client (i.e., hardware handling and communication). In addition, this software handles the physical read / write process to the data stored on the server. Unlike the client, server processes can run on various computers, depending on the application. Mainframes, minicomputers, and powerful microcomputers may all be used as servers. Storage needs, cost, and access speeds determine which machine to use.

Client/Server Architecture

Whereas system architectures developed in mainframe environments are highly homogeneous, with almost all their components coming from a single vendor, system utilities, peripherals, and other network components in client / server systems also differ from mainframes systems in that servers can be upgraded without clients being affected and vice versa.

Client and server processes are physically separated; they operate on separate machines. The server can support multiple clients while providing multi-user applications. The client uses an interface program that runs on the client's workstation and performs such tasks as providing a graphical user interface, protocol processing, and access to server-based resources.

Client / server architectures divide the processing of data between front-end clients and back-end servers. The front-line client uses an application that asks and receives

services from a server on the back end. That is, the client sends data queries to a back-end server, receives results, and then presents them to the user in an attractive and efficient interface.

Connectivity and Communications

Because the usual implementation of a client/server system involves a minimum of two machines, a method of communicating between the machines is necessary. Many methods are available. Which one is chosen depends on the number of machines to be connected, the size of the area they will link, expected amount of network use, type of cable used, connection method used, operating system employed, bandwidth available, and protocols. *A method is chosen depending on these factors and the willingness of management to build for future growth.*

Implementation Issues and Client/Server Guidelines

The implementation of a client/server system involves many issues that organizations should carefully consider. Such items are security, organizational change, and cultural change. These three items are discussed in the following paragraphs.

Security

In most *organizational* situations, people take a very proprietary view of data they have created. However, in a client/server environment, people must transfer the ownership of their data to their organization. A major selling point of client/server systems is that they provide wide access to information, but many organizations are so concerned about this aspect of the client/server architecture that they will not consider moving critical systems away from the centralized model.

The implementation of a enterprise-wide system to control access to sensitive *organizational* and personal data is imperative. According to Patrick Smith, "Users should find security to be invisible when they are authorized for a function and impenetrable when they are unauthorized."(2)

Organizational Change

In the most common client/server implementations, the client function resides on a desktop computer and the server on either a mainframe or minicomputer. In this configuration, development and support personnel are necessary, and they must be familiar with all computer environments. Traditional EI/IT personnel are very experienced in desktop computer systems. However, there are still users out there using the mainframe environment. In those organizations that are still using mainframes, the users have very little experience in desktop computing systems. This fact can inhibit the development of client/server systems in organizations that want to protect the "glass

house" and the security and familiarity it represents. The size and skill sets of such organizations must therefore change to serve the client/server environment.

Cultural Change

The adaptation of a client/server model for enterprise computing inevitably generates some opposition from individuals or groups that perceive the model threatens their position or influence. Their opposition can impede or prevent client/server adoption. If it is adopted, some of these individuals may leave the organization because they cannot learn new skills. Those who change and remain may have to find a new place for themselves within the organizational culture.

Cost Modeling

Applying client/server technology to under-priced applications is turning out to be more expensive than host-based computing. EI/IT managers must develop a comprehensive accounting for their client/server systems' overall costs, across the organizations. That is, apart from their initial investments, EI/IT organizations must develop cost models that will identify future operating costs. If you do not, your EI/IT organizations will be carried away by a bottom-line cost explosion.

Change Management

Many of the benefits realized by EI/IT organizations upon introducing client/server systems technology may come from simply *changing the workflow process.* Often overlooked in the rush to adopt client/server computing technology is the fact that the users must change as well. Such change can also be threatening, however, and staff resistance to it can hurt the EI/IT efforts to adopt client/server computing technology. Therefore, all managers, not just the EI/IT managers, must prepare for the leap and take into account the reaction their staffs may have.

Client/Server Standards

In the open systems environments, there can be several technical combinations among platforms, database management systems, communications alternatives, and productivity environments. EI/IT system management adds yet another layer of complexity. Traditional EI/IT systems come wrapped in the fort of the operating system software and service from the vendor(s). Managing EI/IT client/server systems means controlling a heterogeneous environment with multiple components. A single standard for managing these systems is unlikely to surface soon; EI/IT organizations with standards for hardware and software are candidates for client/server processing technology. However, the new technology (NT) environment is looking like it may be a step in the right direction for multiple platforms.

The Status Quo

Your EI/IT organizations must weigh the benefits of client/server computing technology against its tangible and intangible risks. For some organizations, especially

those with multitudinous engineering workstations and modest (i.e., relatively slow) processing needs, legacy systems may provide the best environment. There are those who feel that client/server systems are preferable only when a EI/IT organization has large computing power requirements and uses few engineering workstations or microcomputers. Several engineering workstations or microcomputers on a network can choke an application if not properly configured. The client/server computing technology does provide added value, but at a price.

Technology Issues

As in any new technology, client/server systems involve many technology issues. These issues are discussed in the following sections.

Hardware

Client/server systems must be available and reliable, ensuring that there will not be a problem.

Availability

The implementation of a client/server system has a two-sided effect: Application development and use is dispersed over a large group of users, but data tend to become centralized because redundancy is reduced. *This situation offers greater flexibility to users, but it also exposes an organization to the risk of productivity loss if a server failure occurs.* Therefore, keeping the servers up and available for processing is a paramount concern.

Providing redundant power supplies, thorough repair or replacement services, quality management, and monitoring of network activities ensure this flexibility. Nevertheless, as one observer put it, "When they work, client/server network environments empower users to work effectively and creatively. But this technology has a catch when something goes wrong; the causes are often difficult to pinpoint**.**"(3)

Reliability

Having enough horsepower to run client/server applications is critical to system reliability. Reliability begins with implementation of system functions, as previously discussed. Then, systems and procedures must be designed and implemented to ensure that the various system components do not interfere with the operation of any other application.

As Patrick Smith notes, "Software must automatically handle multiple user contentions, provide full recovery after failure of in-flight updates, and provide utility functions to recover a damaged magnetic disk."(4)

An often overlooked aspect of client/server design is the importance of the network. *The capacity of an organization's current network should be examined to ensure it can handle the added demands of new client/server applications.*

Software

Client/server software can be judged in terms of its performance and productivity.

Performance

Optimizing performance of EI/IT systems is an important management issue. Client/server applications themselves do not control the transmission of information between a client and the server system; it is controlled by the operating system software. Many vendors sell software, called middleware, to handle the specific communication tasks between the client and the server that are not addressed by the operating system.

System managers can often use additional tools for monitoring network traffic loads, if these are not provided with their operating systems. These tools can be used to detect and correct potential problems before they cause a major network breakdown.

Productivity

A major impediment to improving EI/IT productivity among computer-based workers is the backlog in developing and implementing new systems. In the client/server model, a major portion of the responsibility for developing new applications to meet user needs is transferred to the user, who is given tools to develop applications and access to appropriate enterprise data.

Don't get me wrong here. *Those individuals who will develop other applications or improve the productivity of these applications must be qualified to do so.* Thus, productivity is increased because development time is shortened. Because users get the products (i.e., programs) they want, the usage rates and productivity of these applications is higher than those of applications developed other ways because they are tested immediately as the user goes forth and uses applications they just developed. There must be *software quality control* in place so that the product is tested and integrated as you go.

To ensure productivity and performance, thorough planning must take place before a client/server system is implemented. Steven Roti says that: "Management and planners should be aware of the following *potential pitfalls* in the planning process."(5)

- Too many vendors with incompatible software are in the market.
- Too many versions of software systems are not compatible with other versions from the same vendor.
- There is a lack of proper analysis and design.
- There is a lack of prototyping.
- Systems are under-designed.
- Expectations are too high.

You need to use common sense and yet look to the future when you are planning a client/server environment. Both management and users should be involved with the planning and implementation of this environment. There are many ways to migrate to client/server systems. Paul Winsberg lists eight different methodologies for migrating to a client/server installation.(6)

- Restructure legacy code and data in place.

- Wrap the entire legacy system in an object-oriented cloak.
- Surgically remove the user interface and presentation logic.
- Incrementally rebuild applications, operating two databases in parallel.
- Incrementally rebuild applications, migrating the database files first.
- Incrementally rebuild applications, migrating the database last.
- Rebuild the entire legacy system in a single shot, from the ground up.
- Reengineer the *technical* and business processes. *Move towards enterprise-wide workflow environment.*

Each of these methods has different risks, with the first having the lowest and the last the highest.

Cost Issues

Some of the technical costs associated with client/server systems are not obvious to organizations considering them. The following paragraphs describe client/server cost issues.

Cost Increases

According to several observers, "Average companies spend $1.7 million for their first high-end client/server application."(7) Depending on the size of the Department of Energy (DOE) National Laboratory you can expect to spend several million dollars on hardware and software development to fully convert to a client/server architecture. The cost increases that result from adopting client/server systems fall into two the major areas of training and capacity.

Training

Because the communication between clients and servers is transparent to users, users being trained to operate a client/server application do not require instruction on using the network facilities. Network interaction is handled by the operating system software, in conjunction with the application software. This fact also reduces the amount of user training required to operate a client/server application. However, client/server users require more support than terminal users for two reasons: they have more software at their disposal, and they are performing development work they have never done before with tools from different vendors.

Although the relationship between labor and equipment costs changes with the implementation of client/server systems, total costs may not decrease.

The lack of reliable centralized client/server management tools means that additional personnel are needed to perform system and network management tasks. If the EI/IT organization(s) and/or group do not incur this additional labor cost for maintaining control over dispersed client/server hardware and software, control will pass to the end users. Regaining control when centralized tools become available may be even more expensive.

A major cost in implementing client/server systems involves retraining of EI/IT staff. The balance between labor and equipment costs changes dramatically as configurations change. After installing a new client/server system, Texaco found that it had underestimated training time and cost, which took 50% longer and cost 300% more than anticipated.(8)

Capacity

In the client/server environment, managing capacity involves handling the clients, the servers, and the network as one entity. *Capacity issues include the processing speeds of both clients and servers, client and server physical storage capabilities, and the bandwidth (i.e., information carrying ability) of the network.* Performance analysis determines how close to capacity the various components are operating. Proper capacity management requires simultaneous attention to all three areas, balancing the load of each component and planning for growth.

Companies and/or organizations that implement client/server systems often encounter costs that were never budgeted for in the proper proposal. Some of these unanticipated costs include additional telecommunications, network management, capacity planning, and scalability.

Savings

In the short run, companies that implement client/server systems may not save money because they may incur many cost increases that offset any realized cost savings. The promise of client/server systems is their long-run savings.

Backups

EI/IT computers store two types of information: critical and noncritical. Critical information includes engineering drawings and associated data records and other operating information, the loss of which could significantly affect the ability to continue working on a current or future project. Noncritical information is any other information stored. Both critical and noncritical data should be identified up-front. This doesn't mean that noncritical data can't be changed to critical data, or vice versa, as time goes on. In a file-server system, the servers contain both critical and noncritical data.

Backing-up organizational data is very important. Backing-up a file server requires either copying all the files (critical and noncritical) or selectively copying files. Copying all files is very time consuming. Selectively copying takes less time but is vastly more complex. The frequency with which an organization backs up data depends on the time required to perform this task and the sensitivity of the data backed-up.

A client/server system, when properly implemented, keeps all data in a centralized location on the server. Backing up is simple because the server contains only one type of data and does not need to be selectively copied. The time required is reduced, and backing-up frequently is more feasible.

Backlogs

The inability of overworked systems developers to deliver necessary new systems can affect *your* organization. Implementing client / server technology and transferring the responsibility for most new system development to users eliminates a large portion of the backlog and should reduce costs by facilitating more efficient operations. *However, users need to have the ability to do system development (that is, if they are capable of doing so). This is not as easy as it sounds.*

Processing Costs

As increased amounts of processing occur at the desktop level, overall computational costs will be reduced because processing costs are lower on microcomputers than on mainframes or minicomputers. In addition, currently unused capacity of desktop machines will begin to be used. *A word to the wise; look before leaping into the unknown.*

Client/Server Promises

Client / server systems are designed to reduce an organization's costs and increase its productivity in several ways.

Seamless Access to All Information

The term *seamless* refers to a user's ability to gain access to necessary information without that effort's being hindered by computing and communications resources. The goal is crucial to the advancement of enterprise-wide productivity.

Enterprise-wide Computing

Past computing efforts were generally scattered among an organization's various departments, divisions, and groups; they were often incompatible with one another. *Enterprise-wide computing describes an attempt to unify or integrate the computing resources of an organization to accomplish a common goal.* The architecture and infrastructure of a client / server system should be designed to reduce the complexity of building a single logical system out of many machines, while providing an efficient and reliable system as the end product. Information availability, data organization, data interchange, and data access are also important components of the enterprise-wide computing goal. Finally, the system used to access the data must be transparent to the user. This means the mechanics of locating, accessing, and transmitting the data must be hidden from the end user. All these component parts will allow the system to function as one entity.

End-User Computing.

In recent years, end users have demanded increased numbers of applications as their reliance on software systems has also increased. Their demands have added to systems development backlogs. Client / server systems offer a way to alleviate this situation.

They allow end users to maximize productivity by reengineering work flows, and they eliminate rework by providing increased integrity and quality. The client/server model puts the responsibility for applications in the hands of the end users by giving them access to data and the tools to develop applications.

Information-Oriented Productivity

As organizations learn that EI/IT information is a resource that must be managed, they alter the way they view and handle their organizations' information. The costs associated with handling and storing data become relevant. Access methods, storage formats, and handling methods are more closely scrutinized. *An organization begins to realize that how efficiently they handle their corporate and/or organizational EI/IT information affects their overall company and/or organizations productivity.*

Client/server technology provides a method to help organizations achieve this goal because implementation of this model eliminates the barriers to EI/IT information flow. When information is freely available, the need for redundant data is reduced or eliminated. Reduction of redundancy decreases its cost by removing the need for multiple updates. Productivity is increased through this increased availability because decision makers have access to better information.

Cautions

Drawbacks of Client/Server Systems

In theory, the client/server computing technology sounds great: it allows an organization to rapidly create graphical applications that reflect changing business needs. Hidden beneath the surface, however, are unexpected costs that can make client/server systems more expensive to operate than centralized, host-based systems. Client/server hardware and software components are less expensive than their mainframe equivalents (i.e., legacy systems), but the real costs in operating client/server are in service, support, and administration. One study found that for every dollar spent on client/server systems, organizations spend 65 cents in support.(9)

It has been my experience that technical support is the cost category most often underestimated by EI/IT managers. It can amount to nearly two-thirds of a client/server system.(10) Most of these costs come in the form of people.

Vendors tout client/server systems as the faster, cheaper, and easier alternative to mainframe computing, and the initial costs associated with mainframe computing (i.e., hardware costs) are generally higher than those associated with building client/server systems. However, mainframe hardware and associated peripheral costs are tax deductible, but technical support, the largest client/server costs, are not—and these costs, unlike hardware costs, do not decrease over time. Client/server support costs can run three times the price of systems hardware and software.

Electronic data management is another wild card. Client/server systems store data in physical locations apart from the rest of an organization's data. The fact that these

client/server locations must back-up their data creates some apprehension among EI/IT managers, especially those who are accustomed to working in a mainframe environment in which data is backed up at one time in one place. Backup and recovery in a client/server environment can be expensive.

Distributed networks beg for intruders. The more distributed the network, the greater its vulnerability. EI/IT managers trying to provide client/server applications with mainframe-like security have a few options, however. Many organizations are now retrofitting their client/server applications with security features because they did not offer adequate security from the beginning.

Client/Server Guidelines To Live By

Converting to the client/server computing technology is not easy. It involves changing an organization's hardware, software, and business processes. Most organizations that have adopted client/server computing technology appear to be struggling. Many organizations are delaying their efforts to implement this technology. Experts advise caution and patience, but many managers are overcome by the itch to move to client/server computing technology. I would remind you that there are other risks and rewards. This is not an exhaustive list.

Expectations

Client/server systems are not magical. They do not provide complete, unimpeded data flows, and personnel in organizations planning to implement these systems should be cautioned not to expect unlimited EI/IT information access.

Complexity

According to Paul Gillin, "A distributed system is one in which I can't get my work done because a computer has failed that I've never even heard of."(11) Client/server technology promotes the redistribution of computing resources, but it also introduces a level of complexity organizations have to assume. An organization should evaluate the features offered by client/server products in terms of its actual EI/IT requirements.

Claims

According to Gillin, "Users are being sold a bill of goods on client/server . . . too much attention has been focused on short-term hardware savings and not enough on the cost of people and lack of features. Yes, the client/server environment does let you replace expensive, proprietary computers with cheap, mass-produced ones. But that's about all that's cheap about it."(12)

Investigating Claims

Sound information is needed to make sound decisions regarding a client/server system. Peter Gillin recommends organizations do the following:(13)

- Be skeptical of all claims by vendors.

- Ask for demonstrations.
- Get copies of client/server software for evaluation.
- Get references.
- Research literature or articles on the product.
- Keep internal staff involved in the decision process.

Organizations should also be sure they know where they are going and how to tell when they get there.

Many concerns are being expressed about client/server systems. Many people believe red flags are being ignored, often to the detriment of everyone involved. When the success of a client/server implementation is critical to an organization, due caution should be observed throughout the selection and implementation process. According to John Kiernan:

> The move to client/server offers a unique opportunity to effect radical changes in the way we do business is not just from a technology standpoint, but also from an information standpoint. We have been given the opportunity to correct the weaknesses of past architectures and begin to manage information as a resource, rather than relying on faster technology to solve all of our problems for us.(14)

The Price of Idleness

Although the database technology has not evolved to support advanced forms of client/server computing technology, many organizations are committed to the client/server way of life. Determining if the client/server computing technology is right for a EI/IT organization is difficult. Specifically, if corporations and their EI/IT organizations consider the price of standing put, the difficulty level increases exponentially.

For many organizations, hierarchical management is on its way out, and empowered users are on the way in. Nevertheless, corporations should not scrap their existing systems just to embrace the client/server computing technology without first carefully planning and considering the cost of both.

Closing Comments: The Benefits of Client/Server Computing Technology in the EI/IT Environment

Implementing client/server technology causes changes, both organizationally and culturally. Anticipating and planning for these changes also affects system performance.

In a nutshell, client/server computing technology puts processing power on users' desktops and improves the capabilities of end-user application. Also, It puts processing power where it is needed to address EI/IT issues. It communicates what is happening in the business as it happens. Using client/server technology can also defer costs. Organizations can develop and test applications on client/server systems for a fraction of the cost of developing and testing them on mainframes or high-end minicomputers.

Doing so allows an organization to proceed with high-risk projects with reduced up-front costs.

Organizations using client/server technology can also grow incrementally. Because EI/IT organizations can upgrade hardware or add new applications without affecting existing applications or users, they can easily modernize their systems as the need arises. They can also mix and match computer platforms. Currently, NT will support all Windows, UNIX, and Macintosh platforms.

Client/server applications avoid networks by minimizing the number of data transfers. The users of this technology can access large databases by using highly optimized database servers. Unlike local area network (LAN) users, client/server users do not have to worry about clogging their networks. The failure of one client engineering workstation machine does not paralyze other users' engineering workstations.

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